Menicucci

Conservation II
Science Activities in Energy

DOE/NBB-0013

Science Activities in Energy

Science Activities in Energy, a series of simple, concrete, revealing experiments, was developed especially for students in the fourth through tenth grades.

The purpose of the series is to illustrate principles and problems related to various forms of energy and their development, use, and conservation.

More importantly, *Science Activities in Energy* was designed to help you directly involve students in exploring intriguing scientific questions and in making discoveries on their own.

You don't need to be an expert in science to use these materials. In fact, many of the activities use art, economics, arithmetic, and other skills and disciplines. Since the series stresses investigation and exploration, you are not expected to know the "right" answer to every question.

Each unit in *Science Activities in Energy* forms a cohesive program of instruction on a single topic. Currently, there are units in the following areas: Biomass I, Biomass II, Chemical Energy I, Conservation I, Conservation II, Energy Storage I, Electrical Energy I, Solar Energy I, Solar Energy II, and Wind Energy I.

Most activities in the series can be conducted in the classroom, using materials readily available in any home or school. A few activities require materials purchased from a local or national supplier. The series' developers have made a concerted effort to design activities which use the same materials or materials that can be saved for use in other units.

Each activity begins with a question. At the beginning of the activity, try to get your students to predict the outcomes, even if they lack experience or knowledge to justify their predictions. Urge them to guess! This helps them to become more interested and involved in the activity.

When working on answering a question, each student (or the class as a group) follows the instructions which lead him or her through the activity. This kind of direct participation leads students to other questions—some of which are suggested on the activities and others they generate themselves. The activities encourage exploration by the experimenters on their own.

The series' developers have purposely used metric measurements throughout the experiments. They believe that this will be part of the learning process for many young people and also for some adults.

Each activity is outlined on a single sheet. The sheets can be photocopied for distribution or easily projected on a screen or a wall.

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As the developer of *Science Activities in Energy*, Oak Ridge Associated Universities is anxious to learn how you and your students use the activities, what variations you develop, and any results you find extraordinary.

Please let us know your reactions to the activities. Also, feel free to ask for information on any energy-related topic.

Teachers Guide

Conservation II - 1

Question
How much farther will a car that's twice as heavy go when the same force is applied?

Time
30 to 50 minutes.

Objective
The student will measure the distances the toy cars travel and discover the relationship between distance and weight.

Process Skills
Observing, measuring, organizing data, hypothesizing, and replicating data.

Materials & Procedure Clues
Select matchbox cars that have the same weight. Add clay or washers to one of the cars to double its weight. The plywood board should be secured to a level table or floor. Select rubber bands carefully. Have the students measure carefully.

Concept
The same force causes cars of different weights to move different distances.

Background
Assuming all things are equal, the relationship between the force applied to an object and the speed it attains is uniform. The more massive an object is, the less it will accelerate for a given force.

Although friction is a variable which affects the experiment, the heavier car travels a shorter distance for the same amount of force from the launcher.

Many factors influence gasoline consumption in automobiles: the way a person drives, the type of engine oil, tire pressure, type of tire, speed, etc. However, the weight of a car is one of the major factors which influence the number miles per gallon.

Precautions
None.

Results
The heavier toy car will travel a shorter distance on the plywood board.

Strategies
Before: Predict which car will go farther.

After: Discuss and compare the results of the activity with the class. Have the students do the activity several times. What variables need to be controlled closely? Which car goes farther? How does this relate to the care of automobiles and trucks?

Conservation II - 2

Question
How much horsepower can you produce?

Time
30 minutes.

Objective
The student will identify the unit of measurement for power and measure the power the volunteers produce.

Process Skills
Measuring, organizing data, hypothesizing, and identifying variables.

Materials & Procedure Clues
Measure the height of the stairs accurately with the string. Then, measure the string to determine the height of the stairs.

Students should practice using a stopwatch before beginning the activity.

Concept
When one machine does the same amount or more work than another in a shorter amount of time, the first machine produces more power than the second.

Background
The most horsepower a person can produce for a short time is one horsepower. A person can only produce about .10 horsepower for longer periods of time.

Work (W) is defined as the mathematical product of weight which is lifted (w) to a given height (h). W = w x h.

If a 110-lb student ran up stairs that are 12 feet high, he did 1320 foot-pounds of work. 1320 (W) = 110 (w) x 12 (h).

If the student climbed the stairs in five seconds, he produced 264 foot-pounds of work in one second. $\frac{\text{(1320 foot-pounds of work)}}{\text{five seconds}}$

A machine that does 550 foot-pounds of work in one second has produced one horsepower. Therefore, the student produced .48 horsepower. $\frac{\text{(264 foot-pounds)}}{\text{550 foot-pounds}}$

Precautions
Students should be careful not to trip and fall while running up the stairs. Be sure others do not use the stairs during the experiment. Don't run down the stairs. It is dangerous!

Results
The most horsepower anyone can produce for a short time is one horsepower. Students will produce about 1/3 to 1/2 horsepower. About one-tenth horsepower is all that can be produced for long periods of time.

Strategies
Before: Have each student predict how many seconds it will take to run up the stairs.

After: How much horsepower was produced by each volunteer? Discuss the results of the activity.

Conservation II - 3

Question

Will an R-1 material let heat through twice as fast as an R-2 material?

Time

50 minutes.

Objective

The student will measure the R-value of gypsum and other materials used as home insulation.

Process Skills

Observing, measuring, hypothesizing, and organizing data.

Materials & Procedure Clues

Use 1/2" gypsum board.

Glue the sections of gypsum board together before starting the activity.

Be sure the 100-watt bulb and the thermometer are touching the gypsum board.

Be sure to time how long it takes the temperature to rise 5°C.

Concept

All building materials conduct heat. The R-value of a material is a measure of its resistance to the flow of heat.

Background

R-value is a measure of the resistance to heat flow of materials used in building construction.

One way to understand what R-value means is to compare materials which have different R-values. The speed that heat flows through materials is one way to measure their relative R-values.

In general, there is an inverse relationship between heat loss and R-value. A higher R-value means that less heat is lost from a building.

R-values of typical construction materials

Material	R-value
Gypsum board or sheetrock, 1/2"	0.45
Plywood, 1/2"	0.62
Asphalt shingles	0.44
Wood shingles	0.94
Structural insulating boards	1.32
Expanded polystyrene, 1"	3.57

Precautions

Be careful students do not burn themselves on the 100-watt bulb.

Results

It takes about twice as long for heat to go through R-2 insulation as it does R-1 insulation.

Strategies

Before: Discuss how R-values are determined. Is insulation value and R-value the same?

After: Identify what materials make the best insulators. Is gypsum board a good insulation material to use in homes? Why don't people use stone or bricks as insulation?

Conservation II - 4

Question
What is the approximate R-value of 3/4" wood?

Process Skills
Observing, measuring, controlling variables, and hypothesizing.

Time
50 minutes.

Materials & Procedure Clues
Be sure the 100-watt bulb and the thermometer are touching the wood. Place the thermometer on the wood at the same height where the bulb touches the wood.

The wood should be dry.

Objective
The student will compare how long it takes to raise the temperature 5°C through a piece of wood with how long it takes using insulators with known R-values.

Concept
All building materials conduct heat. The resistance to the flow of heat is measured by a unit called R-value.

Background

The R-value of wood depends on several factors, such as its moisture content and its density. Some kinds of wood, cedar for example, have a very high R-value. A house built with five-inch thick cedar walls has R-11 walls. Since wood has a higher R-value than stone, a wooden house's walls generally will have a higher R-value than a stone house.

Although the method used to measure R-value is complicated, interested students should research how it is done and try it outside of class.

The method used for measuring R-value in this experiment is easier. A number of materials with known R-values are tested along with one with an unknown R-value. After the data is graphed, the material with the unknown R-value is read from the chart. The accuracy of the results depends on how carefully the data is obtained and graphed.

R-values for common construction materials

Material	R-value
5/8" plywood	0.79
1/2" plywood	0.63
3/8" plywood	0.47
1/4" plywood	0.31

Precautions
Be careful when using the 100-watt bulb.

Results
The R-value of the plywood will be between 0.75 and 1.00.

Strategies
Before: Discuss the reasons for using wood in constructing homes.

After: Is pine a better insulator than gypsum board? What are the variables in the activity? What is required to insulate a home well?

Conservation II - 5

Question
How much longer will it take for the temperature to rise 5°C through one pane of glass compared to three panes of glass?

Time
50 minutes.

Objective
The student will compare the time required to raise the temperature 5°C through one pane of glass with three panes of glass.

Process Skills
Observing, controlling variables, measuring, and hypothesizing.

Materials & Procedure Clues
Be sure the 100-watt bulb and the thermometer are touching the glass. Each pane of the three-paned window should be separated by a piece of cardboard that is 1-cm thick.

Concept
Glass is not a very good insulator. However, if air is sealed between glass panes its insulation ability improves.

Background
The greatest heat loss in a house occurs through the windows. In the winter when humidity is high, the moisture in the air condenses on the inside of the windows. Although triple-pane windows have an even higher R-value, generally it is more economical to use double-pane windows. Compared to the walls in a house, triple-pane windows have a very low R-value.

In planning an energy-efficient house, most of the windows should be on the south side of the house. Very few, if any, should be on the north side. In the summer, the south-facing windows must be shaded by an overhang or trees.

The R-value of a single-pane window is approximately 1; a double-pane window is approximately 2; a triple-pane window is not quite 3.

Precautions
Students should handle the glass and bulb carefully.

Results
The results will vary greatly. The three pieces of glass will take at least three times as long to raise the temperature 5°C than one piece of glass.

Strategies
Before: Emphasize the need to control the variables in the activity.

After: Where should windows be located in a house? Why? Discuss the need for energy conservation practices in buildings.

Conservation II - 6

Question
How much more light does a bulb give off from a distance of 1 foot compared to a distance of 3 feet?

Time
50 minutes after constructing the photo light meter.

Objective
The student will compare how much light is obtained by the light meter at one-foot and three-foot distances from the bulb.

Process Skills
Observing, measuring, controlling variables, and hypothesizing.

Materials & Procedure Clues
Have students assemble the light meter before conducting the activity. Be sure to explain how to read the light meter. Check the wiring.

Concept
The intensity of illumination from a point source of light is inversely proportional to the square of the distance to the light. For example, a distance twice as far from the light source will give one-fourth the illumination.

Background
Lights used in a house are not point sources. Therefore, they do not follow the inverse square law exactly. However, the light at twice the distance is far less than one half.

Light sources are measured in candle-power — a measure of how much light is produced compared to a standard candle. A 100-watt bulb has approximately 100 candle-power. A one-candle-power bulb produces one foot-candle of illumination, one foot away. Therefore, a 100-watt bulb produces about 100 foot-candles, one foot away.

Most light meters are made with solar cells and sensitive electric meters. See the activity sheet for light meter construction details.

Since most photo light meters are calibrated in foot-candles, the measurements in this experiment are made in feet instead of meters.

Precautions
Be careful when working with electricity.

Results
Students should obtain three to four times more light 1 foot away from the bulb than 3 feet away from the bulb.

Strategies
Before: Explain how the light meter works.

After: How much light is needed to read comfortably? How do people use light?

Conservation II - 7

Question
How many 25-watt bulbs equal the light output of one 100-watt bulb?

Time
50 minutes after constructing the photo light meter.

Objective
The student will determine how many 25-watt bulbs equal the light output of one 100-watt bulb.

Process Skills
Observing, measuring, controlling variables, and hypothesizing.

Materials & Procedure Clues
Use the photo light meter developed in *Conservation II, Activity 6* to measure the light output. Be sure to hold the light meter 60 cm from the bulbs.

Concept
The efficiency of a bulb increases with its power. Low wattage bulbs give off less light per watt than higher wattage bulbs.

Background
The efficiency of small incandescent bulbs increases with the power of the bulbs. That is, you get more light output for a given unit of electricity used.

All bulbs in a house are connected in a parallel circuit so they operate independently of each other.

The 25-watt bulbs should be connected in parallel as shown on the activity sheet. Use porcelain sockets that do not have exposed terminals.

When taking the light readings, the room should be dark. Bunch the sockets as closely together as possible. Place the photo light meter the same distance from the 25-watt bulbs as you do for the 100-watt bulb.

Precautions
Be careful when working with electricity.

Be sure to use a parallel circuit as illustrated.

Results
It will take at least five 25-watt bulbs to equal one 100-watt bulb.

Strategies
Before: Introduce different size bulbs to students. Why are they different? How do they work?

After: How do we measure light? How efficient are different types of bulbs, such as long-life, unfrosted, soft-white, or square bulbs?

Conservation II - 8

Question
How much energy is saved when a dimmer switch is used with a 100-watt bulb?

Time
Two 50-minute class periods to construct the apparatus and conduct the activity.

Objective
The student will determine if a dimmer switch is energy efficient.

Process Skills
Observation, measuring, controlling variables, and hypothesizing.

Materials & Procedure Clues
Be sure to check the students' wiring before plugging into the wall outlet. Read the AC ammeter and photo light meter carefully. Take several readings.

Concept
Usually, dimmer switches only serve aesthetic purposes. Care must be taken in selecting various home apparatus and appliances that claim to be energy efficient.

Background
Modern electronic dimmers are efficient devices waste little energy compared to rheostats used in the past. However, dimmer switches should be used mainly for their aesthetic appeal, not their energy efficiency. They do not save energy compared to the amount of light that is lost.

Light bulbs are made of tungsten, a material that has low electrical resistance when cold. The hotter tungsten becomes, the more light is produced.

When a dimmer switch is used, it lowers the average amount of current flowing through a bulb, thus cooling it. The bulb gets dimmer and also uses less power. However, the power doesn't decrease as much as the light output.

A smaller bulb operating at normal high temperatures gives more light per watt than a larger bulb and a dimmer switch.

Precautions
Be careful when working with electricity. Be sure the wires are connected securely and that all exposed wiring is covered with electrical tape. Be sure to follow diagram exactly. All parts are connected in series, one following the other.

Results
Lower wattage bulbs will provide more of a cost savings than a dimmer switch.

Strategies
Before: Discuss how ammeters and photo light meters work. Discuss how a dimmer switch works.

After: Compare the results the students obtained in the activity. Why are dimmer switches so popular? Are they energy efficient?

Conservation II - 9

Question

Who can make the strongest recycled paper?

Time

50 minutes.

Objective

The student will make recycled paper from old newspapers.

Process Skills

Observing, measuring, and hypothesizing.

Materials & Procedure Clues

Follow the recipe carefully. Let the paper dry on the screen for one or two days, depending on the thickness of the pulp on the screen and the humidity level. Peel the recycled paper off the screen carefully. Students should be encouraged to experiment in making recycled paper. Allow them to use other methods.

Concept

Newspaper, cardboard, and other scrap paper can be recycled again and again to better utilize our natural resources and to reduce the energy required to make paper

Background

Recycling materials to make paper dates from when paper was made from old linen clothes. When this supply became inadequate to meet the demand for paper, the paper makers turned to trees. It takes a great deal of energy to harvest the trees, shred them, and separate the fibers from the lignin which holds the fibers together. Waste chemicals are also produced. Getting rid of these chemicals could mean heavy pollution of streams and rivers. Water purification associated with paper making is an expensive, energy-consuming process.

Precautions

Do not overfill the blender.

Results

Surprisingly good paper can be made, but it will be off-white to gray in color.

Strategies

Before: What are some uses for recycled paper? Why isn't it used more often?

After: You may want to develop an apparatus to test the strength of the paper. How much energy would be saved by recycling paper? What else could be recycled to save energy? What cannot be recycled?

Conservation II - 10

Question
How much energy does it take to heat the water for your shower?

Time
30 to 50 minutes.

Objective
The student will determine how many kilocalories are used to heat the water for a shower.

Process Skills
Observing, measuring, predicting, and controlling variables.

Materials & Procedure Clues
Be sure to collect the water with the pail for one minute. Measure it carefully. Students can use their showers at home or those in the athletic locker room at school.

Concept
Heating and storing hot water takes a great deal of energy. Conserving hot water is useful in saving large amounts of energy and money.

Background

Some methods of heating and storing hot water are expensive and wasteful. Since fuel has to be burned to generate electricity, electric water heating is not as efficient as gas water heating. In fact, only about one-fourth of the energy from the fuel used to make electricity is available to heat water.

There are several ways to conserve hot water. One quick way is to reduce the amount of time spent in the shower. Another easy way to cut down on hot water usage is to use cold water when possible, for example when washing clothes. Energy-saving shower heads also reduce hot water usage.

Heat can be saved by wrapping additional insulation around a water heater. Instant-demand water heaters, which eliminate the need for storage water holding tanks, are also available.

Solar water heaters are an effective way to conserve energy and still supply adequate amounts of hot water.

Precautions
None.

Results
A nine-minute shower at 7.71 liters per minute with the shower water at 53°C and the cold water at 15°C will use approximately 293 kc per minute or 2737 kc total.

Strategies
Before: How do water heaters work?

After: Discuss the need to control the variables in the activity. What costs more, a bath or a shower? How much would a daily shower cost for a month? A year?

Conservation II - 11

Question
What is the least expensive battery to use in an electronic device or toy?

Time
One hour or more depending upon the toy and battery used.

Objective
The student will identify the most economical battery (dry cell) to use in electrical devices or toys.

Process Skills
Observing, measuring, classifying, hypothesizing, and controlling variables.

Materials & Procedure Clues
Obtain an assortment of batteries: carbon-zinc, alkaline, etc. Keep records of the battery costs. Use each battery until the device or toy stops operating. If a battery lasts longer than one class period, turn it off and restart it the next time the class meets.

Concept
The least expensive battery may be the most expensive to operate. The use of limited-life, lower-priced carbon-zinc batteries may be far more expensive than purchasing alkaline or other types of batteries.

Background

The dry battery is not really dry, but has its moisture sealed in the cell. All cells contain a metal and a chemical solution which tends to dissolve the metal as the battery is used. The metal is the source of the electrons which flow through the device back to the positive pole of the battery. The internal structure and the nature and purity of the chemicals determine the cost of a battery and how long it will last.

Battery power is relatively expensive. It can only be justified where portable power is required and the amounts needed are small. For example, to find out battery cost for 1000 hours of use, determine how long a battery might last. For our example we assumed each battery would last ten hours. Therefore, it would take 100 batteries to last 1000 hours. If a battery costs 25¢, total cost would be \$25.00 for 100 batteries lasting a total of 1000 hours.

$$\frac{1000}{10} = 100 \times \$.25 = \$25.00$$

Precautions
Do not short circuit a battery since that will shorten its life drastically.

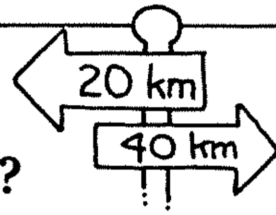
Results
Generally, alkaline and higher quality batteries cost less to operate.

Strategies
Before: Discuss the use of batteries in the home.

After: Discuss the results of the experiment.

Student Activities

How much farther will a car that's twice as heavy go when the same force is applied?



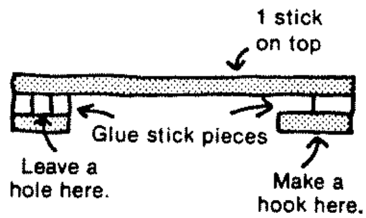
Materials

- Plywood board (30 cm × 60 cm × ½-inch thick)
- Masking tape
- Metric ruler
- 2 Small nails
- Popsicle sticks
- White glue
- Hobby knife
- Rubber bands
- Small toy car
- Metric scale
- Assortment of metal washers
- Textbooks
- Hammer

Set Up and Conduct Your Experiment

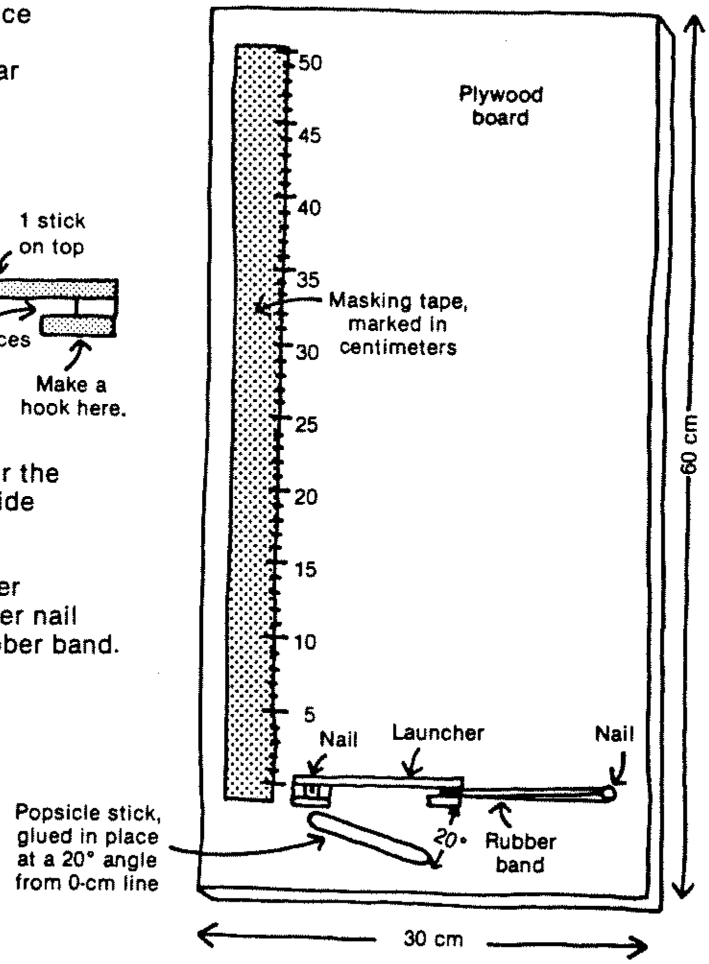
Construct a device to measure the distance a toy car travels.

Build a popsicle stick-launcher.



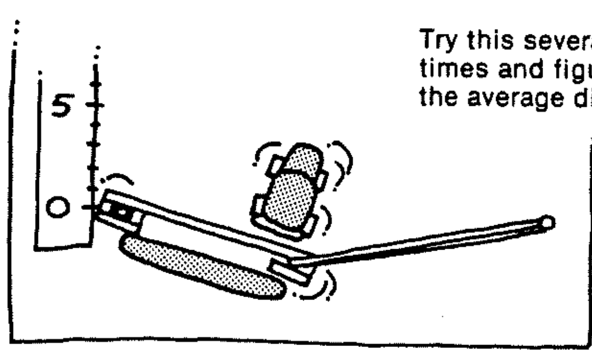
Slip the hole over the nail on the left side of the board.

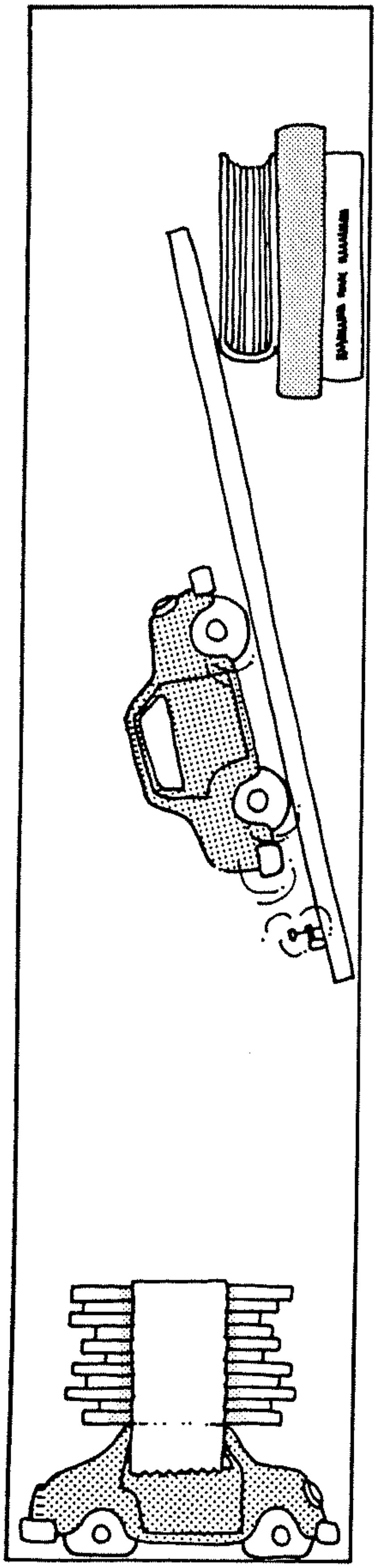
Hook the launcher tightly to the other nail with a strong rubber band.



Launch the toy car. Measure and record how far it travels.

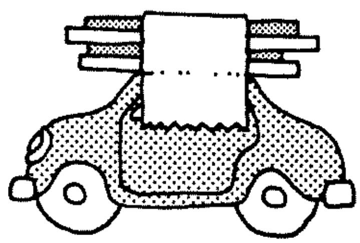
Try this several times and figure the average distance.





Record Your Results

		Distance traveled	
		Car without weights	Car with weights
Level board	1st Trial		
	2nd Trial		
	3rd Trial		
	Average		
Inclined board	1st Trial		
	2nd Trial		
	3rd Trial		
	Average		



Add enough washers to double the weight of the car.

Try the experiment again.

Then, launch the car downhill. (Add one or more textbooks at the end opposite the launcher.) Record the distance the car travels with and without weights.

Summary Question

Does the lighter car go twice as far as the heavier one?

Other Ideas to Explore

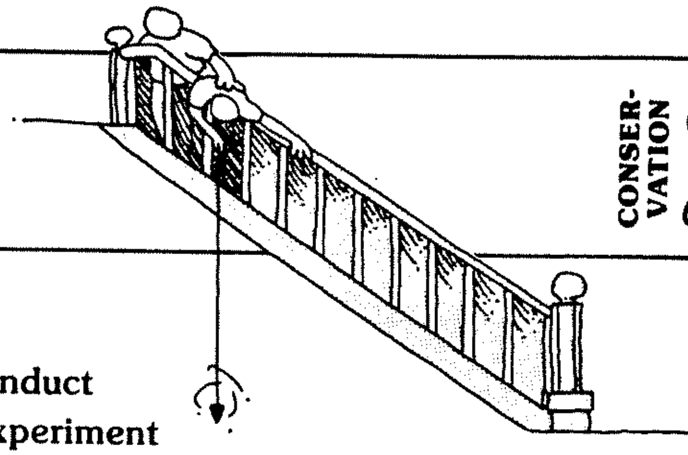
How much weight do you have to add to reduce the distance the car travels by one fourth?

How does this relate to gasoline consumption?

Would the same relationships hold if more force were used?

How does the weight of a car carrying several passengers compare to the weight of an empty car? How does weight affect the distance it travels? the gasoline consumption?

How much horsepower can you produce?



CONSERVATION 2

Materials

String and weight

Staircase

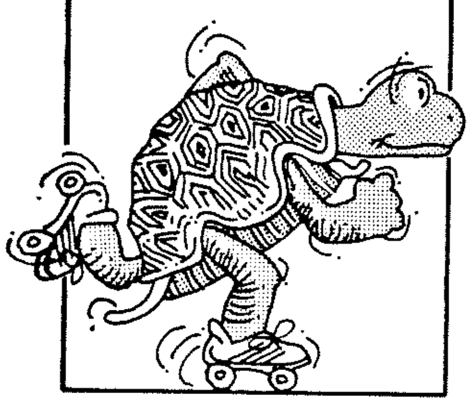
Stopwatch

Yardstick

Scale

Calculate Horsepower

$$HP = \frac{\text{weight of volunteer (lbs)} \times \text{height of stairs (ft)}}{550 \times \text{volunteer's time (seconds)}}$$



Set Up And Conduct Your Experiment

Measure the height of the stairs by dropping a weight tied to a string from the top. Record the height in feet.

Then, weigh your volunteer runners. Be sure to vary the size of the volunteers.

Have each volunteer run up the stairs as rapidly as possible while you record each one's time in seconds.

Calculate the horsepower each volunteer produced.

Summary Question

Could you produce twice as much horsepower by running up stairs that are twice as high?

Height of staircase = ________ ft.

Volunteer			
Name	Weight	Time	HP

Other Ideas to Explore

Try calculating the amount of energy produced by using the metric system.

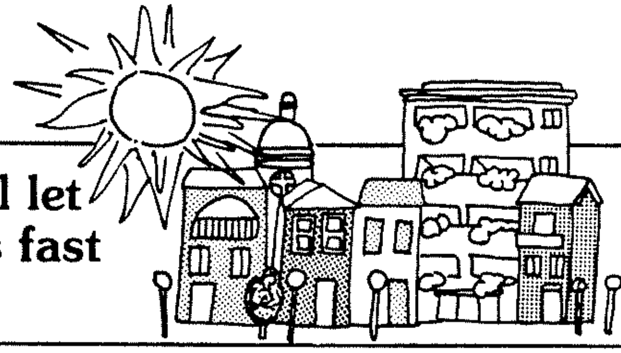
Try the same experiment with a ramp. Would the length of the ramp make any difference in the amount of horsepower that is produced?

Can girls produce as much horsepower as boys?

Do athletes generate more horsepower than non-athletes?

How long can your volunteers continue to produce horsepower? What happens?

Will an R − 1 material let heat through twice as fast as an R − 2 material?



CONSER-
VATION 3

Materials

6 Pieces gypsum board
(20-cm square
× 1.25-cm thick)

Thermometer

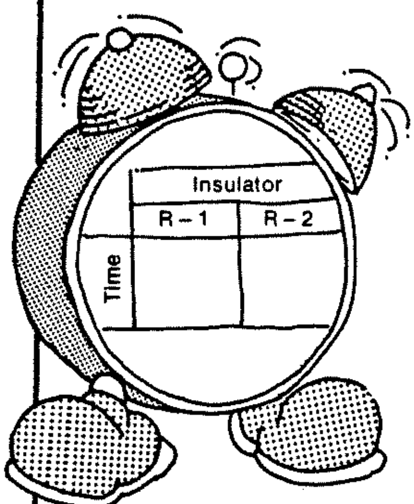
White glue

Masking tape

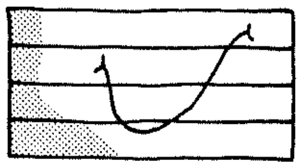
100-Watt bulb

Ceramic socket
with a plug

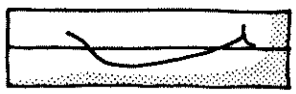
Stopwatch



Set Up And Conduct Your Experiment



Glue four pieces of gypsum board together to make an R-2 insulator.

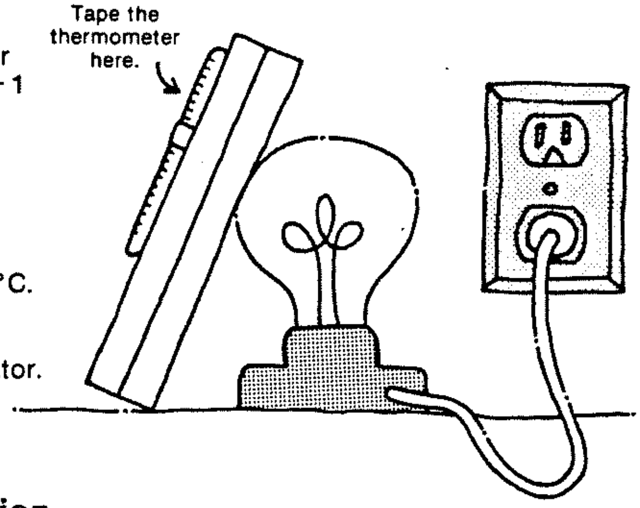


Glue two pieces of gypsum board together to make an R-1 insulator.

Tape the thermometer to one side of the R − 1 insulator. Rest the other side of the insulator on the bulb.

Measure the time it takes for the temperature to rise 5°C.

Try the experiment using the R − 2 insulator.



Summary Question

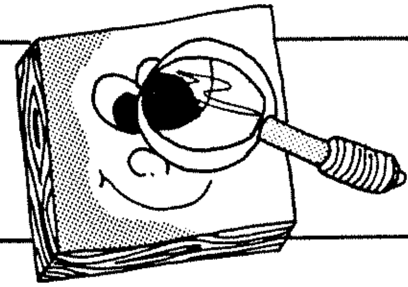
What are some factors, in addition to R-value, that people use in deciding the type of insulation they will buy?

Other Ideas to Explore

Try the experiment using different insulation materials. Experiment with one thickness. Then, experiment with two.

Would three thicknesses in insulation be three times better than one thickness?

What is the approximate R-value of 3/4″ wood?



CONSER-
VATION
4

Materials

4 30.5-cm Square pieces of plywood (one each of the following thicknesses: 1/4", 3/8", 1/2", and 5/8")*

1 30.5-cm Square wood sample (1/4-inch thick)*

Thermometer

Masking tape

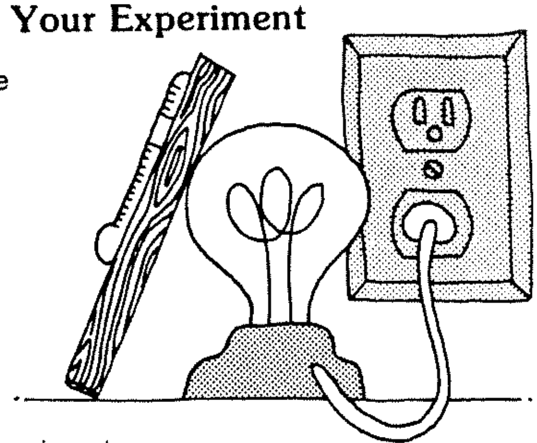
Ceramic socket with a plug

100-Watt bulb

Watch with a second hand

*available at hardware or building supply stores

Set Up And Conduct Your Experiment

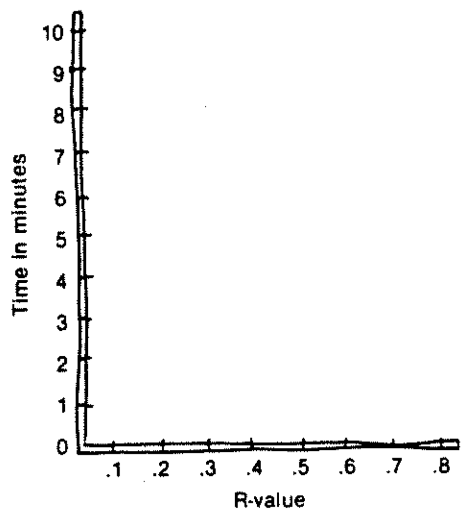


Tape the thermometer to one side of the wood sample. Rest the other side of the sample on the bulb.

Measure the time it takes for the temperature to rise 5°C.

Try the experiment using the various thicknesses of plywood.

Graph the results of your experiment.



Insulator		Time in minutes	R-value
	1/4″ Plywood		.31
	3/8″ Plywood		.47
	1/2″ Plywood		.63
	5/8″ Plywood		.79
	Wood		

Using the graph and your data, what is the approximate R-value of the wood sample?

Summary Question

Did you find the R-value of the wood sample to be a good, poor, or average insulator compared to plywood?

Other Ideas to Explore

Test other woods for their insulation value.

Make your own insulator from waste materials you find at home and test its R-value.

How much longer will it take the temperature to rise 5°C through one piece of glass compared to three pieces of glass?

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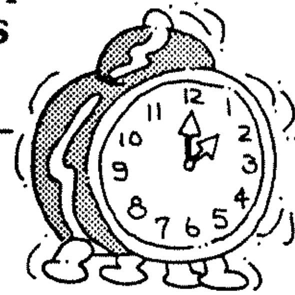


Materials

3 Pieces of glass (25-cm square)

2 Pieces of corrugated cardboard (25-cm square × 1-cm thick)

Masking tape

Ceramic socket with a plug

100-Watt bulb

Thermometer

Watch with a second hand

Hobby knife

Metal straightedge

	1 glass piece	3 glass pieces
Starting temperature		
Time to raise temperature 5°C		

Warning

Tape the edges of the glass to avoid cut fingers. Also, the glass gets hot! Watch your fingers.

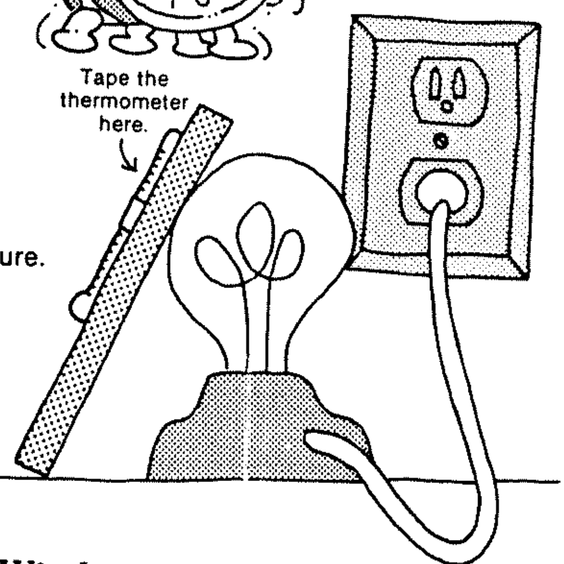
Set Up And Conduct Your Experiment

Tape the thermometer to one side of a glass piece. Rest the other side of the glass piece against the bulb.

Record the starting temperature.

Measure the time it takes for the temperature to rise 5°C.

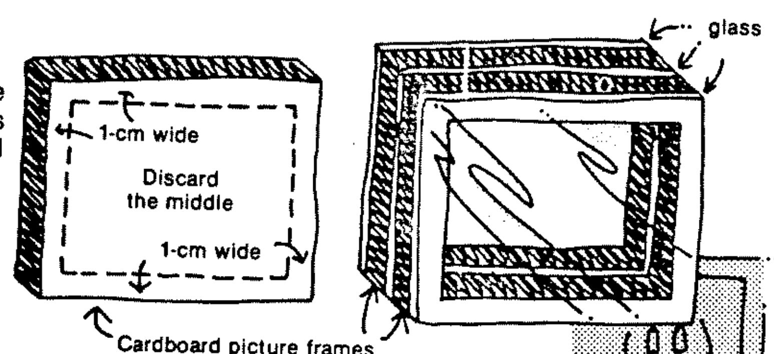
Try the experiment using a three-paned window.

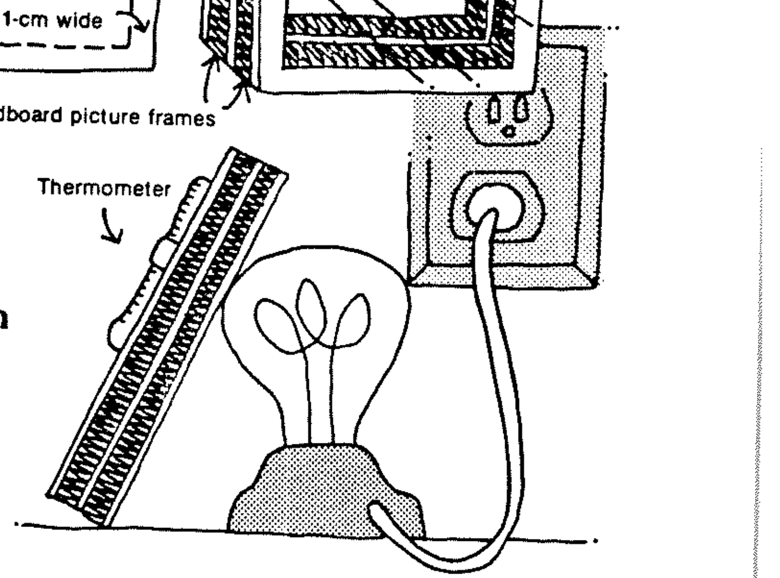


Make A Three-paned Window

Cut the middle out of the cardboard pieces and discard. You will have two picture frames with 1-cm borders on all sides.

Place the cardboard between the three pieces of glass and tape them together.



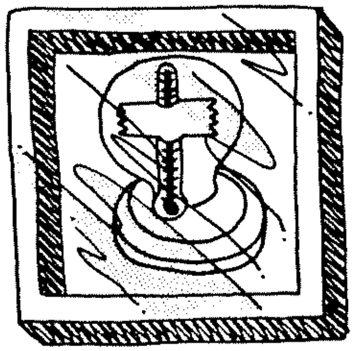


Summary Question

Does one piece of glass allow a 5°C temperature rise three times faster than three pieces of glass?

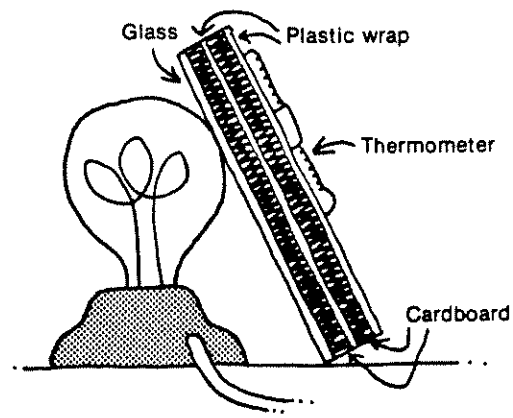
Other Ideas to Explore

Change the spacing between the pieces of glass. Is a cardboard picture frame with a 2-cm border a better insulator than one with a 1-cm border?



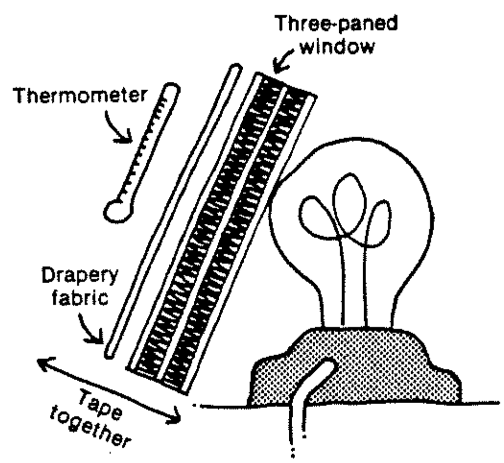
How does the heat from the bulb get to the thermometer in this experiment?

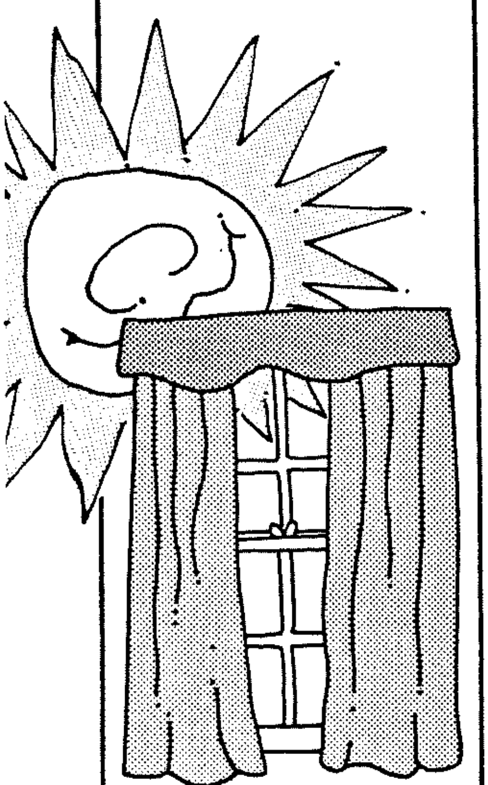
Try substituting plastic wrap for two of the pieces of glass.



Try covering the outside of the three-paned window with drapery fabric before taping on the thermometer.

How much longer does it take to reach a 5°C rise in temperature?

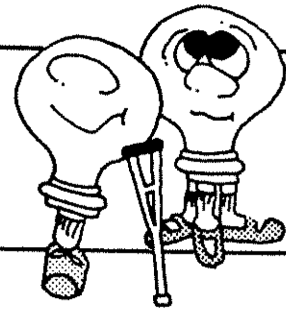




How can you use windows in a house to help keep it warmer?

Call your local power company to find where energy-efficient homes are located in your community. Visit and analyze them. How many energy-saving ideas were used in the construction?

How much light does a bulb give off from a distance of 1 foot compared to a distance of 3 feet?



CONSER-
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Materials

Ceramic socket with a plug

100-Watt bulb

60-Watt bulb

Yardstick

Photo light meter*

*available at camera stores, borrow one from a photographer, or make your own

Make A Light Meter

Solar cell

500-Ohm potentiometer

0-50 Microammeter

#22 Stranded, insulated hookup wire

Solder

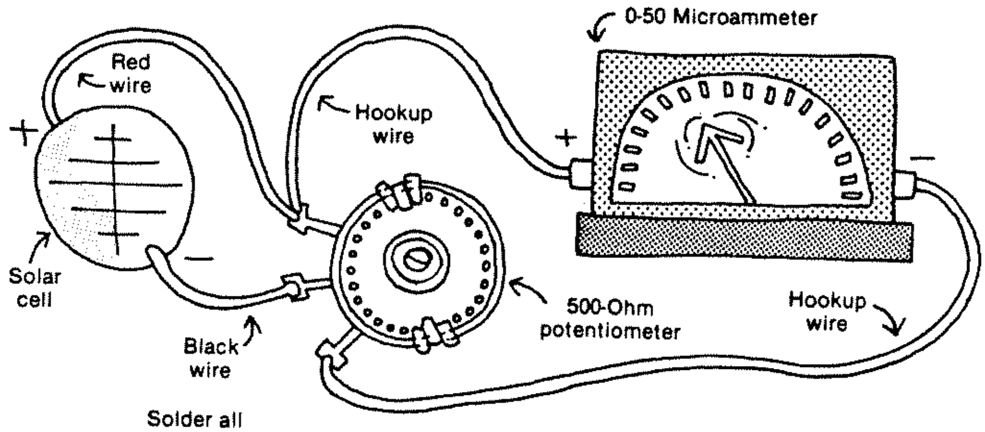
Soldering iron

Note

The room must be almost dark!

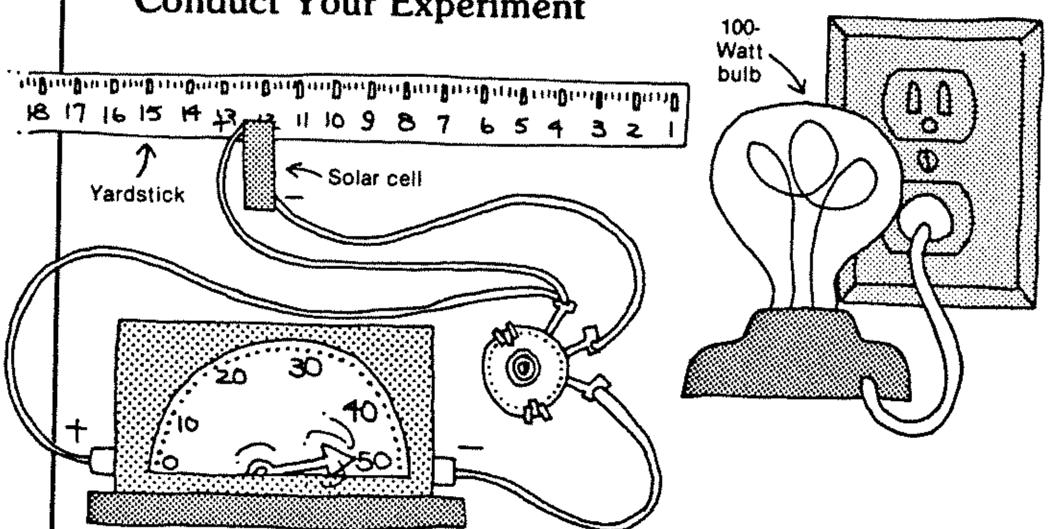
Set Up Your Experiment

Follow this pictorial diagram to make a light meter. (The schematic diagram is on the other side.)



Solder all connections to the solar cell and potentiometer.

Conduct Your Experiment



Calibrate your light meter by placing the solar cell one foot from a 100-watt bulb. This is approximately 100 foot-candles.

Distance	Amount of light in foot-candles
1 Foot	
2 Feet	
6 Feet	

Adjust the potentiometer to read full scale on the microammeter (50 amps). The scale will be linear, so a reading of 50 is 100 foot-candles, 25 is 50 foot-candles, etc.

Now, take readings at three and six feet and record your results.

Summary Question

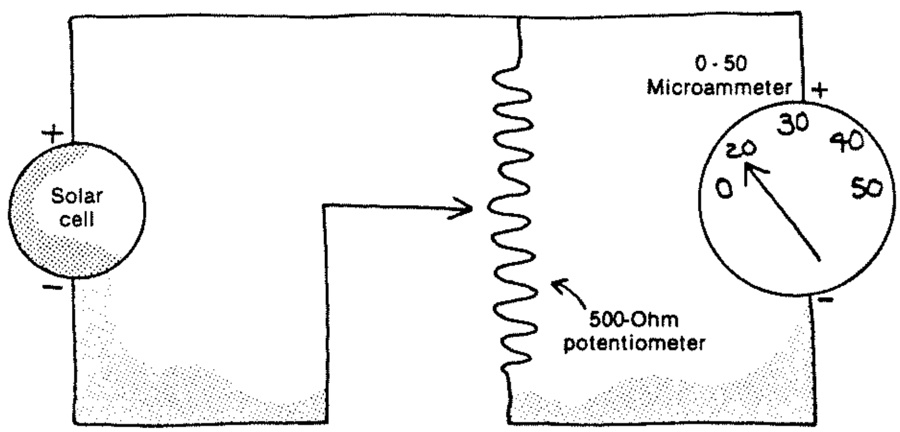
Does the illumination fall off uniformly as the distance increases?

Other Ideas to Explore

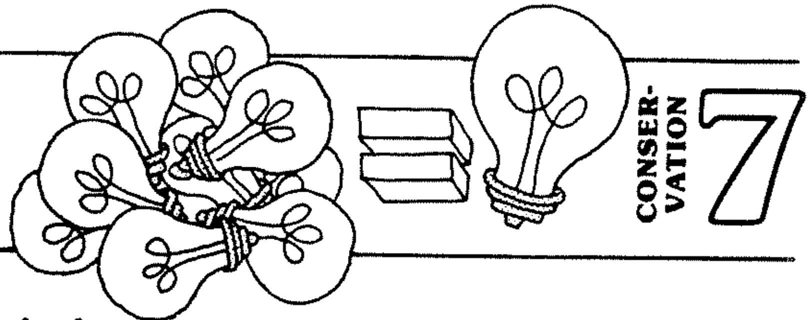
Experiment with bulbs of different wattages. How do the results compare? What results would you expect from fluorescent bulbs?

To test the accuracy of your measurements, place a candle one foot from the solar cell and check the results.

Light Meter Schematic Diagram



How many 25-watt bulbs equal the light output of one 100-watt bulb?



Materials

Ceramic sockets*

Lamp cord with attached plug

2 Meters of #18 hookup wire (stranded and insulated)

Photo light meter**

Electrical tape

Metric ruler

25-Watt bulbs

100-Watt bulb

*ask your school custodian for some spare ones

available at camera stores, borrow one from a photographer, or make your own (see ***Conservation II, Activity 6*)

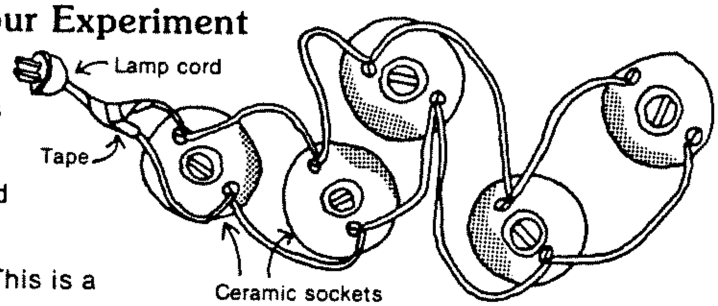
Note

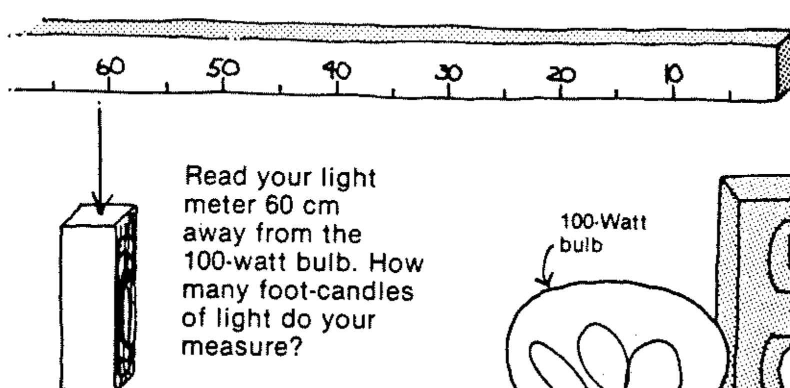
The room must be almost dark!

Set Up And Conduct Your Experiment

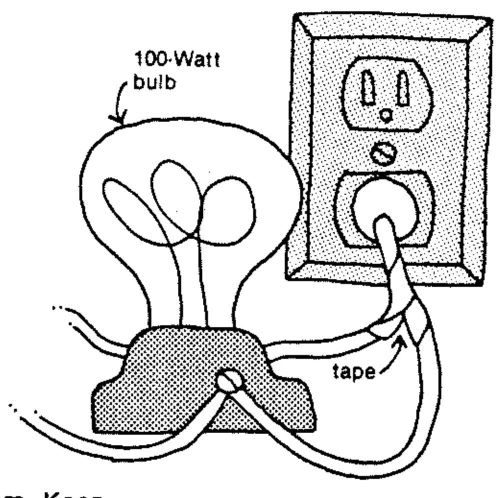
Wire the ceramic sockets like this.

Tape all exposed wires very carefully with electrical tape. This is a parallel circuit.

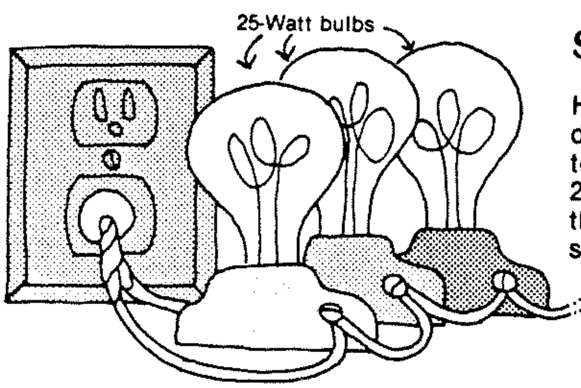




Read your light meter 60 cm away from the 100-watt bulb. How many foot-candles of light do your measure?

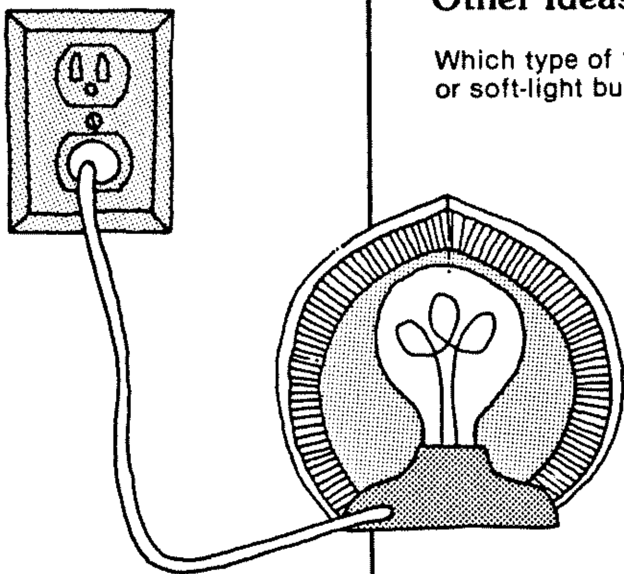


Replace the 100-watt bulb with a 25-watt bulb and read the light meter from 60 cm. Keep adding 25-watt bulbs to the parallel circuit so their light outputs read together on the meter.



Summary Question

How many ceramic sockets did you have to wire to get enough light from 25-watt bulbs to equal the light from a single 100-watt bulb?



Other Ideas to Explore

Which type of 100-watt bulb gives the most light: a long-life, unfrosted, or soft-light bulb?

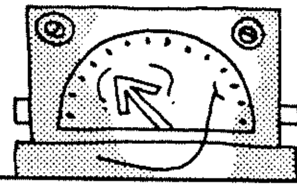
Add a reflector of some kind and measure the amount of light you get from a 100-watt and a 25-watt bulb. Measure the difference in light output with and without the reflector.

Visit a hardware store and ask for a device designed to increase the life of a light bulb by five or more years. The device (a diode) is sold under many names. Measure the amount of light produced when using a diode.

Warning

Watch your fingers around ceramic sockets. Electricity is dangerous!

How much energy is saved when a dimmer switch is used with a 100-watt bulb?



CONSER-VATION 8

Materials

Ceramic socket

Lamp cord with attached plug

100-, 60-, and 25-Watt bulbs

2 Meters of #18 hookup wire (stranded and insulated)

Electrical tape

Photo light meter*

Metric ruler

Dimmer switch

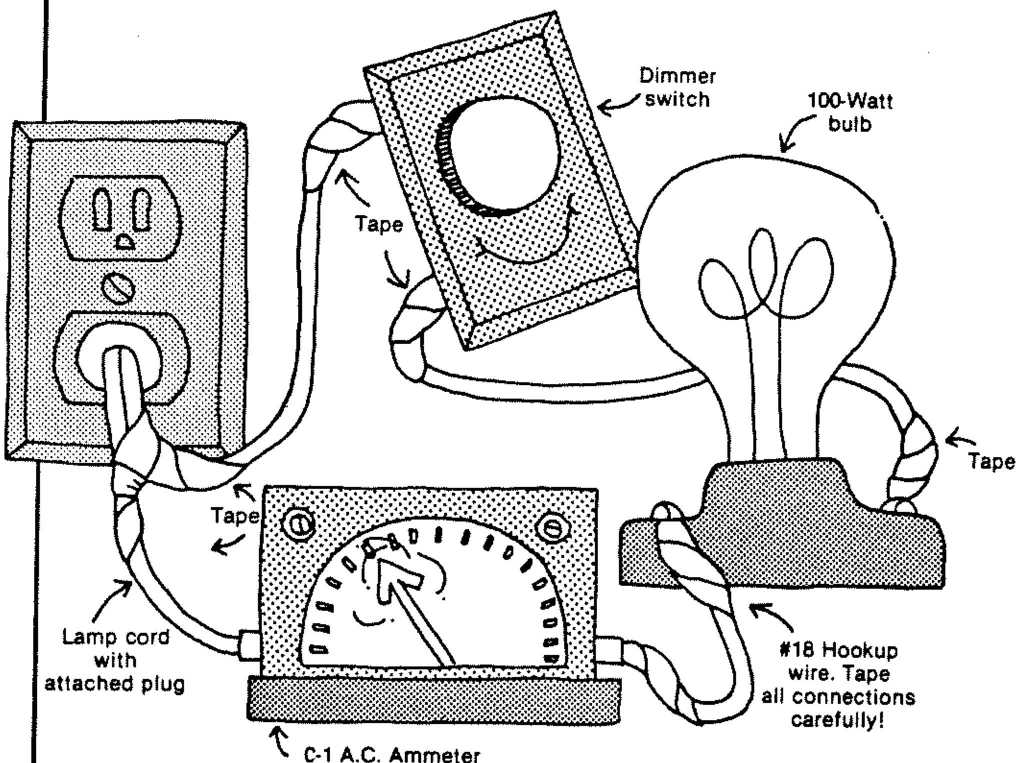
0-1 A.C. Ammeter

*available at camera stores, borrow one from a photographer, or make your own (see ***Conservation II, Activity 6***)

Note

The room must be almost dark!

Set Up And Conduct Your Experiment

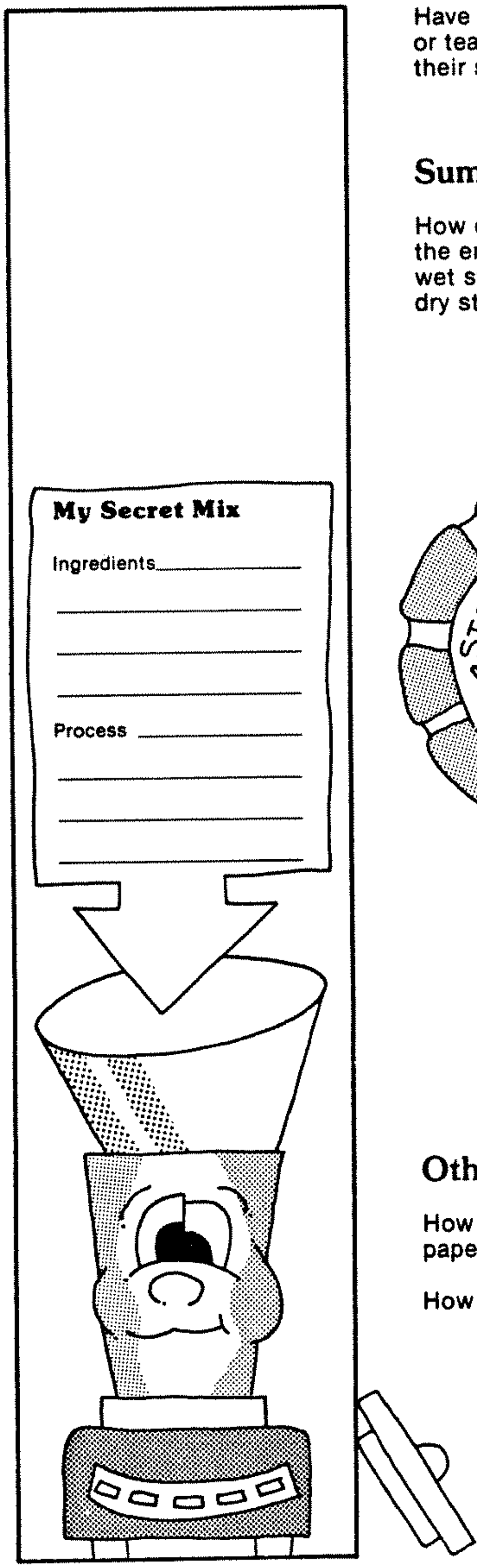


Using the different bulbs, measure and record the light output in foot-candles at 30 cm and the current in amps at each dimmer setting.

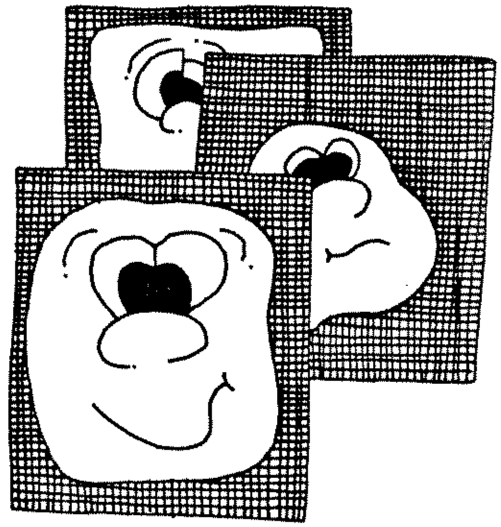
Bulb size			Amps	Light output in foot-candles
	100-Watt	No dimmer		
		½ Output		
		¼ Output		
	60-Watt	No dimmer		
		½ Output		
		¼ Output		
	25-Watt	No dimmer		
		½ Output		
		¼ Output		

Summary Question

Which method saves more energy for the same amount of light output: using lower wattage bulbs or dimming higher wattage bulbs?

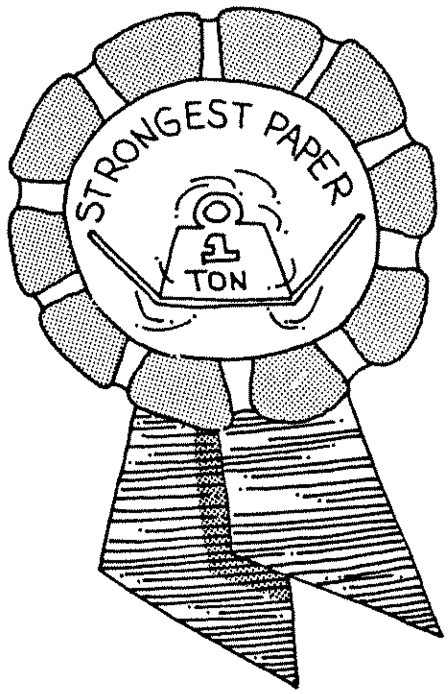


Have each student or team make their secret mix.



Summary Question

How can you test the entries for wet strength and dry strength?



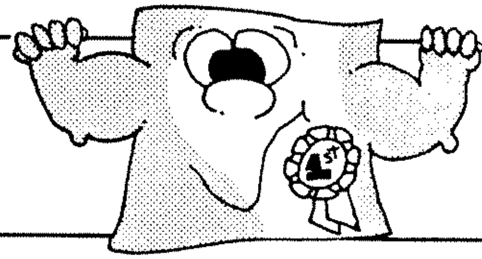
Award a badge to the winner. Be sure to make it with recycled paper!

Other Ideas to Explore

How could you make colored paper? Could you make recycled white paper?

How does recycling paper save energy?

Who can make the strongest recycled paper?



CONSER-
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Materials

Wire screen pieces (about 25 cm × 32.5 cm each)

Blender

Old newpapers

Rolling pin

Starch suspension*

Felt pieces** (about 25 cm × 32.5 cm each)

* Make a Starch Suspension

Combine one cup of cornstarch with two cups of water. Mix thoroughly before using.

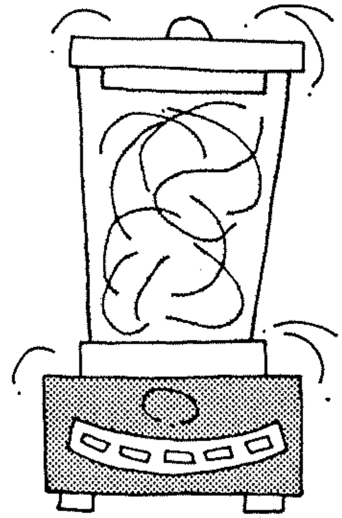
**optional

Set Up Your Experiment

Cut or tear a newspaper page into small pieces and soak them in water.

Pour off the excess water and place the pieces in a blender. Add three tablespoons of starch suspension and blend at high speed until it looks like thick soup.

Quickly pour the mixture onto a piece of wire screen, spreading it evenly.



To remove excess liquid, roll the rolling pin over the mixture while it is on the screen. Peel off the wet paper and dry it overnight.

For a smoother-textured paper, allow the mixture to drain on the screen. Then, cover it with a piece of felt.

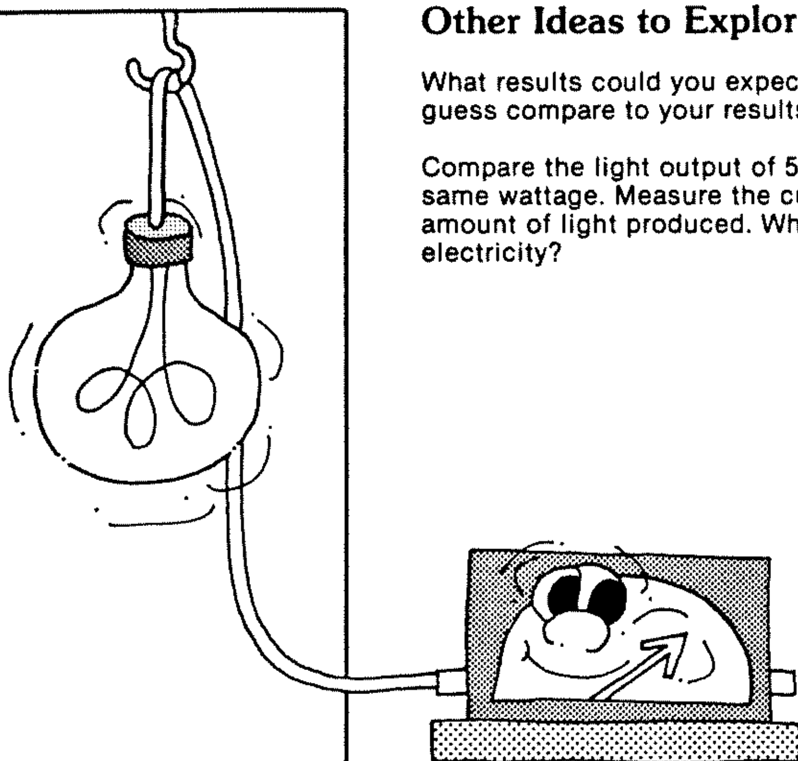
Turn the screen over on the felt and peel the screen off carefully. Cover the paper with another piece of felt before rolling it.

Set Up Your Contest

Now that your know how to make paper, decide on the rules for the class.

Official Rules

- Can you use newpaper only? Are other types of papers allowed, such as homework?
- Can you use only the standard starch suspension? Are other mixtures allowed?
- What is the minimum or maximum paper thickness?
- May colors be added?
- How many pieces of paper should be made by each student?
- Are teams allowed to participate?

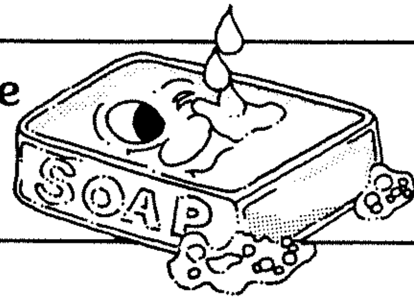


Other Ideas to Explore

What results could you expect from fluorescent bulbs? How does your guess compare to your results?

Compare the light output of 5-year bulbs with a standard bulb of the same wattage. Measure the current each one uses and compare the amount of light produced. Which one produces more light per unit of electricity?

How much energy does it take to heat the water for your shower?



CONSER-VATION 10

Materials

5-Gallon bucket

Metric measuring cup

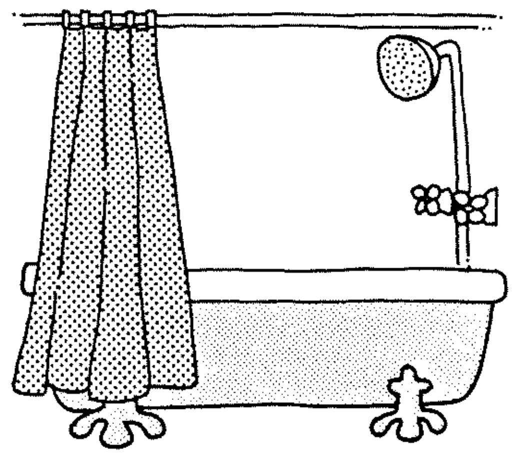
Clock

Thermometer

Calculate the Energy Used

Energy used in kilocalories = liters of water used per minute × difference in water temperature × total time of shower.

Set Up And Conduct Your Experiment



Measure and record the temperature of the cold water out of your shower faucet.

Turn on your shower faucet like you were going to take a shower. Adjust the water to your usual shower temperature.

Measure the temperature of your shower water.

Collect the water in a bucket for one minute and record the number of liters used.

How many liters of water do you think you normally use when taking a shower?

Take a shower as you normally do. Record the length of time your shower water is actually running.

SHOWER DATA

Temperature of cold water ________________ °C

Temperature of shower water ________________ °C

Difference in temperature ________________ °C

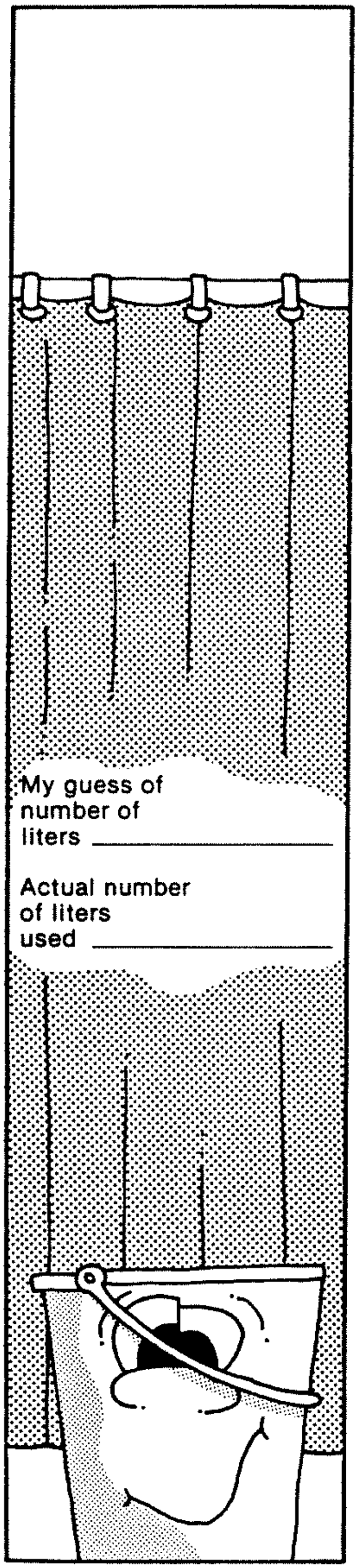
Liter of water in one minute ________________

Total time in shower ________________

Total number of liters used ________________
(liters per minute × total time in shower)

Summary Questions

Did you use more or less energy than you thought you would? How does your energy use compare to others?



Other Ideas to Explore

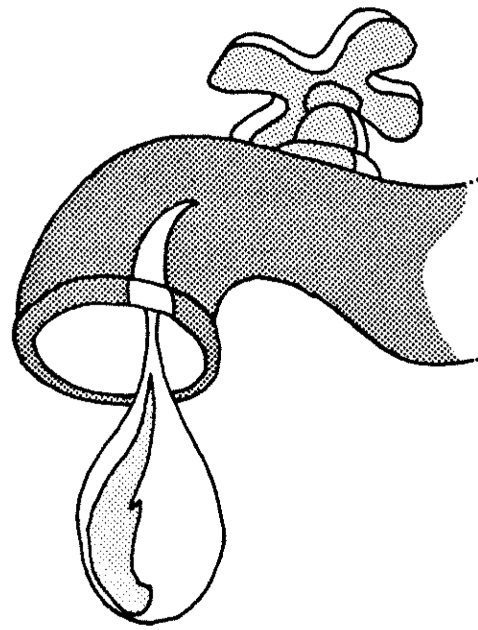
How much energy could you save by installing a water-saving device in your showerhead?

Does a tub use more water than a shower? How much?

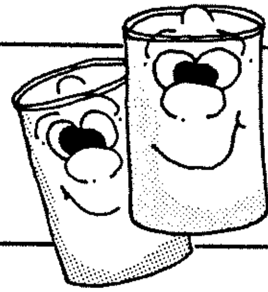
How much energy could a dripping hot water faucet waste?

What other ways can you use to save hot water?

Try keeping a record of your showers and note any differences on your electric meter. (See ***Electrical Energy, Activity 16.***)



What is the least expensive battery to use in an electronic device or toy?



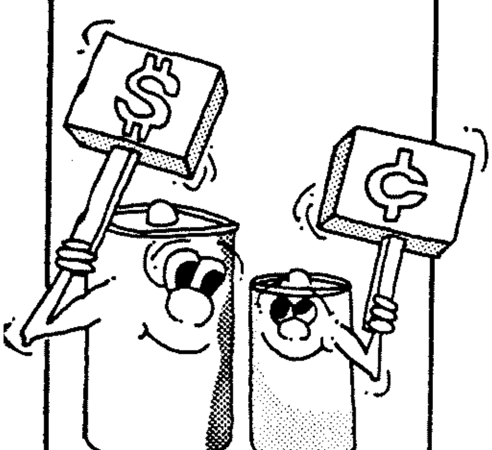
CONSER-VATION 11

Materials

Batteries of all kinds, from the cheapest available to rechargeable types

Clock

Battery-powered electronic device or toy

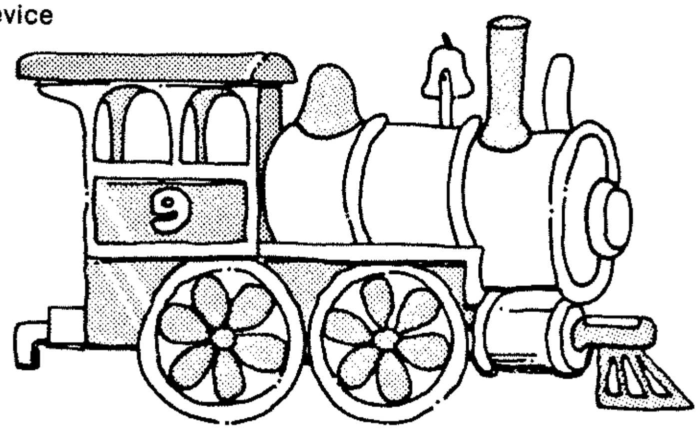


Set Up And Conduct Your Experiment

Place a set of batteries in the electronic device or toy and operate it until it stops.

Record the amount of time it takes for the device to stop working.

Test the other batteries in the same way and record the results.



Type of battery	Cost of one battery	Number of hours it worked	Cost per 1000 hours of use*

*Use this formula.

$$\text{Cost per 1000 hours of use} = \frac{1000}{\text{Number of hours battery worked}} \times \text{Cost of battery}$$

Summary Question

Which battery is cheapest to use?

Other Ideas to Explore

Is the most expensive battery always the best for every use?